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Studies on the Relation between Metabolism and Phototaxis of *Chlamydomonas snowiae*[1]

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In a previous paper some factors affecting the phototaxis of the green alga *Chlamydomonas snowiae* Printz were investigated (Mayer and Poljakoff-Mayber, 1959). The effects of light, temperature and some metabolic inhibitors were described, as was the action spectrum of the phototactic response.

The problem of phototaxis has recently been reviewed by Bendix (1960). Halldal (1958, 1959, 1960) has investigated in some detail the phototactic behaviour of *Platymonas* and other algae. In none of these papers has the relation between metabolism and phototactic response been clearly established. As far as the behaviour of *Chlamydomonas* is concerned, it was previously noted that its phototactic response is extremely variable (Mayer and Poljakoff-Mayber, 1959). In the present paper, attempts to establish the nature of some of the factors causing this variability and to relate them to the metabolism of the algae will be described.

Methods

The organism used was *Chlamydomonas snowiae*, which was cultured on a previously described medium (Mayer and Poljakoff-Mayber, 1959). However, while previously the algae were usually cultured in Erlenmeyer flasks, for these experiments they were grown in 1 liter Roux bottles which were constantly shaken with a slow airstream passing through the solution. Phototaxis was determined by observing the concentration of the algae on the side of a 5 mm wide cuvette when only a small spot was illuminated (Mayer and Poljakoff-Mayber, 1959). Motility of the organisms was estimated by direct observation under a microscope.

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[1] This work is part of a M. Sc. thesis of T. S.

Pigments were extracted from the algae with acetone, which left a white residue of colourless cells. The absorption spectrum of the extract was determined using a Beckman DU spectrophotometer. In order to compare the absorption spectrum of different cultures, or those having undergone different treatments, the following procedure was adopted. The optical density at all values was multiplied by a factor which brought the optical density of the particular extract to 1.500 at 430 mμ. Following this treatment, a difference spectrum could then be calculated. This treatment is of course open to some criticism on various grounds, but it made it possible to demonstrate some of the differences which occur in the pigments in the algae following various treatments.

Oxygen uptake was studied using conventional Warburg techniques at 25°C. in the dark. The algae were centrifuged from the medium, resuspended in distilled water, and the dense suspension used for measurements. Inhibitors, when used, were added to the suspension at the beginning of equilibration, some 30 minutes before readings were begun. Readings were continued for about an hour.

Cell counts were made in a Neubauer haemocytometer and protein estimated by the method of LOWRY *et al.* (1951). Other special experimental techniques will be discussed in the relevant sections of the results.

Results and Discussions

The phototactic reactions

Lack of phototaxis in a culture may be due to one of two reasons: absence of motility in the cells or absence in motile cells of a tactic response to light. Both phenomena were observed. Motility was frequently low or absent in old cells. This lack of motility was not always associated with palmelloid stages. Frequently, single cells were observed to be non-motile. However, in other cases, cultures which were 100% motile did not show phototactic response, indicating that changes in taxis can occur without changes in motility. It is not certain to what extent motility and tactic movement are correlated. In many cases where some factor increased the tactic response in a culture, the overall motility of the cells also showed some increase.

The phototactic reaction of *Chlamydomonas* is towards the light, not towards the highest light intensity. This was demonstrated by the simple experimental setup, similar to that used by HALLDAL (1959), illustrated in Figure 1. In both cases the cells accumulated at the side of the cuvette

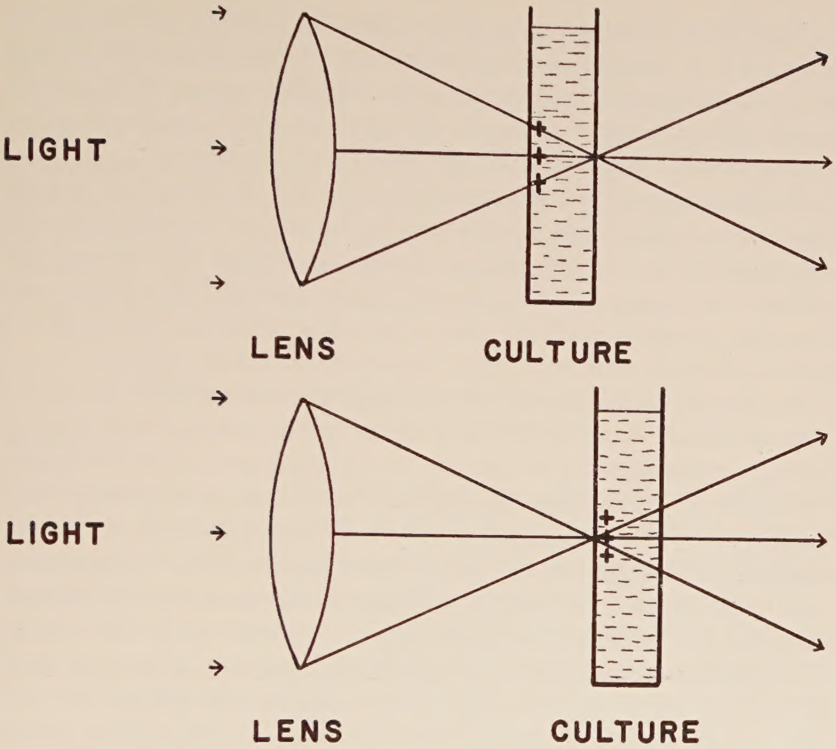

Fig. 1. The effect of direction and intensity of light on phototaxis of *Chlamydomonas snowiae*. + signs indicate where cells concentrated.

nearest the light, although the highest light intensity in one case was on the side farthest away from the source of light. Thus *Chlamydomonas* cells can clearly differentiate between light intensity and direction of light.

Factors increasing the phototactic response

The procedure of growing the organism with constant shaking was adopted when it was noted that such cultures responded much better to light than those which were not shaken. Shaking prevents settling and also concentration of the algae at the liquid-air interphase. In shaken cultures a high proportion of the *Chlamydomonas* cells is in the motile stage. Whether this is merely a result of physically preventing the algae from settling or whether their physiological age is affected is unclear.

Only fairly young cultures were phototactic. Cultures more than ten days old (i. e., ten days after inoculation) showed little phototaxis. Young cells may be regarded as those being in a logarithmic phase of the growth curve. However, growth curves of this organism were found to be rather complex and have therefore not yet been fully analysed.

Phototaxis could not be induced in very old cultures. The lack of phototaxis in such cultures was not due to the accumulation of toxic substances in the medium. When cells were centrifuged off from such old cultures and young cells resuspended in this medium, their phototactic response increased markedly after a period of about 24 hours. Resuspension in fresh medium or water did not have such an effect.

The factors responsible for this increased response were not identified. The substances concerned are heat stable and of low molecular weight, as they can be removed by dialysis. As *Chlamydomonas* cells are known to excrete polysaccharides, glycolic acid, and oxalic acid (LEWIN, 1956; ALLEN, 1956), these substances were tested. "Soluble" starch, 0.5%, had a similar effect on phototaxis as had "old" medium. This is presumably due to the presence of soluble polysaccharides present in commercial "soluble" starch, which has been partially degraded by acid treatment.

The organic acids had only a slight effect on phototaxis. Fractionation of the "old" medium after evaporation, using various solvents, did not give just one fraction in which activating substances were present. Most of the activity was water extractable and insoluble in ether or ethanol. Probably more than one compound is involved.

Darkness has a profound effect on the subsequent phototactic response of cells. Cells placed for 24 hours or more in the dark before testing showed greater phototaxis than the controls. The optimal period in the dark was found to be two or three days. Very weak light acted in the same way, but only after a longer period. The effect of strong light in preventing this dark-adaptation was not restricted to a particular wavelength. More or less all wavelengths, obtained by the use of Corning glass filters, prevented adaptation. Filters used transmitted red, green, blue or yellow light (Corning filters No. 2414, 4084, 3966, 5330, 3482).

The phenomenon of dark-adaptation (i. e., improvement of tactic response by keeping algae in the dark) has been reported by a number of authors (MAST and HAWK, 1936; MAST, 1932; SHETTLES, 1937). These workers showed that dark-adaptation occurred after short periods in the dark. BRUCKER (1954) tested longer periods and HALLDAL (1960) reported that *Platymonas* cells reacting negatively became positive in their reaction if kept in the dark or in red light overnight, while they remained negative if kept in yellow light. This seems to show some similarity to observations reported here. Dark-adaptation seems to be a more general phenomenon. It is unlikely that this adaptation is directly connected with the absence of photosynthesis. Were this true then chlorophenyldimethylurea (CMU), which is known to inhibit photosynthesis rapidly (see table 4), should also affect phototaxis, which was not the case. Moreover, the cells of *Chlamydomonas* contain a very large amount of storage materials and the pyrenoid could be clearly observed by staining with I–KI, even after several days in the dark.

Changes associated with phototactic response and prevention of the response

Respiration

As phototaxis is an energy-requiring process it seems possible that changes in the rate of respiration might be associated with the presence or absence of response. The oxygen uptake of young and old (i. e., responding and non-responding) cultures was tested. Young cells have a higher rate of respiration than old cells. Cells resuspended in "old" medium which became phototactic had a higher rate of respiration than before they were resuspended (Table 1). This increase of respiration, about 25%, seems to indicate some relation between respiration and tactic response.

Table 1. Effect on respiration of cells by suspending them in medium obtained from old or young cultures
(Cells resuspended 45 minutes before beginning measurement)

	Cells from old culture oxygen uptake µl/h/		Cells from young culture oxygen uptake µl/h/	
Cells resuspended in	10^4 cells	unit of protein	10^4 cells	unit of protein
Old medium	35	1.36	48	1.46
Young medium	27	1.06	41	1.25
Distilled water	27	1.06	39	1.17

Old culture 60% motility, no phototaxis. Young culture 90% motility, strong phototaxis.

However, when the respiration of motile cells kept in the light was compared with that of motile dark-adapted cells, a different situation obtained. Dark-adapted cells (see above) had a very much lower rate of respiration than the non-responding cells which had been kept in the light. This difference, about 50%, is present both on the basis of respiration per cell and per unit of protein (Table 2).

Table 2. Effect of dark-adaptation on respiration of *Chlamydomonas*

Treatment	Oxygen uptake µl/h/ 10^4 cells	Oxygen uptake µl/h/ unit of protein
Two days in light	19	2.58
Two days in darkness	8	1.30

Culture in light 70 % motility, no phototaxis. Culture in darkness 50 % motility, weak phototaxis.

As a marked effect of 2,4-dinitrophenol (DNP) on phototaxis had been observed previously (MAYER and POLJAKOFF-MAYBER 1959), this effect was studied in greater detail. It was found that the main reason why DNP stopped tactic response was that it completely prevented motility of the algae. The effect of DNP concentration on both respiration and motility was studied (Table 3). It will be seen that the lower DNP concentrations increased oxygen uptake appreciably while higher concentrations suppressed it. Motility of the cells was usually markedly affected only at the highest concentrations. However, results were somewhat variable in different experiments, because of differences in the age of the culture examined and consequent changes in sensitivity to DNP. Nevertheless, these results are consistent with the view that DNP acts as a true uncoupling agent on *Chlamydomonas*, and its rapid effect on phototaxis may be ascribed to this action.

Table 3. Effect of DNP on respiration and motility of *Chlamydomonas*
(DNP added half hour before beginning of experiment. Movement tested 90 minutes after addition of DNP and compared with initial motility. Initial motility of culture 60 %, phototaxis absent.)

DNP concn. M	0	5×10^{-5}	7.5×10^{-5}	10^{-4}	2.5×10^{-4}	5×10^{-4}	7.5×10^{-4}	10^{-3}
Oxygen uptake µl/10^4 cells/h	20	18	22	21	24	29	31	10
Motility at end of experiment % initial	100	100	100	100	100	80	30	0

A more direct proof of this interpretation was sought. It should be possible to reverse the inhibition caused by DNP by the addition of ATP to the cultures. However, it was noted that not only did ATP not reverse inhibition, but it rapidly inhibited movement of the cells. At a final concentration of 10^{-2}M ATP, motility was prevented within a few minutes. Lower concentrations had a similar effect but took longer to act. This effect and the possibility of interaction of DNP and ATP must be studied over a wider range of concentrations.

Thus no direct relation between taxis and respiration could be established. A relation between taxis and energy utilisation does seem to exist. This seems to be concerned with ATP metabolism. The possible importance of ATP in flagellar movement has been discussed by HOFFMANN-BERLING (1959). WEBER (1958) discusses certain cases where ATP can inhibit protein stretching induced by calcium, which is a somewhat similar result to that observed here.

A number of other inhibitors of metabolism were investigated. Some of the results are listed in Table 4. It will be seen that CMU was without any effect whatsoever on either phototaxis or motility. Most of the other results reconfirm earlier findings. It is of considerable interest that coumarin, which may act as an uncoupling agent in respiration, affects motility and phototaxis rapidly and at lower concentrations than most of the other inhibitors except DNP.

Table 4. Effect of some metabolic inhibitors on motility of cells (The results show the concentration of inhibitor reducing motility by 50% in the period stated)

Inhibitor	M. concentration effective after 60 minutes	 24 hours	 1 week
NaF	5×10^{-2}	5×10^{-2}	10^{-2}
DNP	7×10^{-4}	5×10^{-4}	3×10^{-4}
NaCN	10^{-2}	5×10^{-3}	5×10^{-3}
$NaAsO_2$	10^{-2}	5×10^{-3}	5×10^{-3}
CH_2ICOOH	5×10^{-3}	10^{-3}	10^{-3}
o.phenanthroline	3×10^{-4}	10^{-4}	5×10^{-4}
Coumarin	10^{-3}	5×10^{-4}	
CMU[1]			2.5×10^{-5}

A very effective means of reversibly inhibiting phototaxis and movement of *Chlamydomonas* is by means of CO_2. If a stream of CO_2 is bubbled through a motile culture, all movement stops immediately. When the stream of gas is stopped and the algal culture shaken for a while, motility is resumed. A narcotic effect of CO_2 seems to be involved.

Pigments

It seemed possible that phototactic response of motile cultures might be related to pigments in the cells. In the absence of suitable equipment

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[1] The maximum concentration tested was 7.5×10^{-5}M.

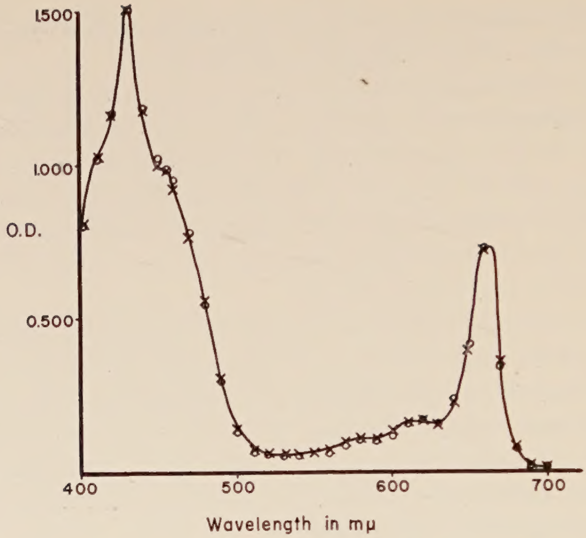

Fig. 2. Absorption spectrum of acetone extract from young (x) and old (0) cells.

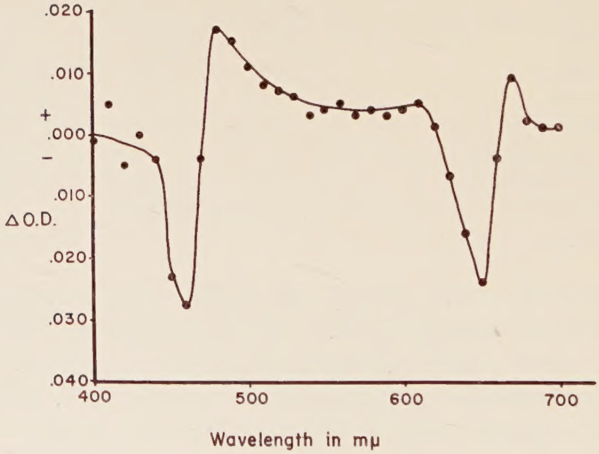

Fig. 3. Difference spectrum of absorption of extract from young and old cells (see Methods).

to measure absorption spectra of entire cells rapidly, the pigments were extracted from cells showing difference in their response. The absorption spectra of these extracts were measured. The general shape of these

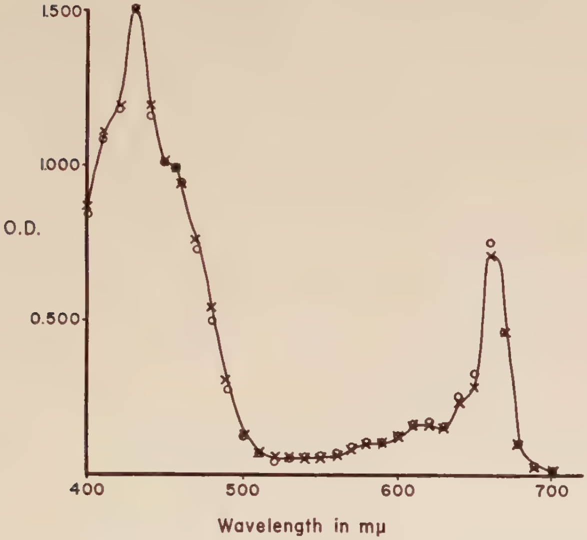

Fig. 4. Absorption spectrum of acetone extracts from dark-adapted (x) and non-adapted (0) cells.

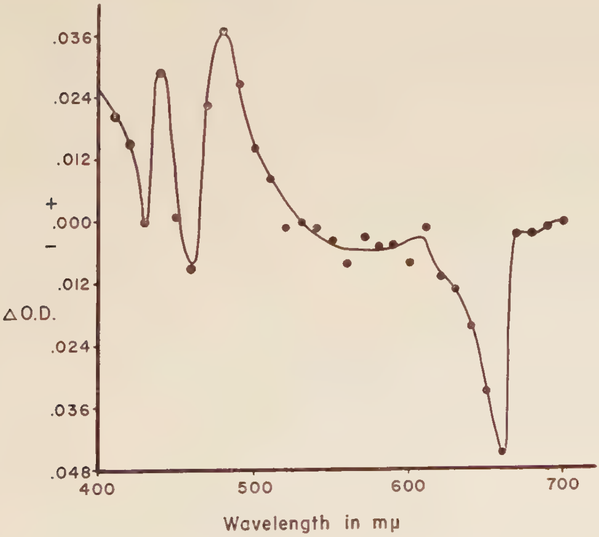

Fig. 5. Difference spectrum of absorption of extract from dark-adapted and non-adapted cells (see Methods).

spectra was always the same and is dominated by the spectrum characteristic of chlorophyll. However, when the spectra were adjusted, as described under Methods, and the difference spectra plotted, some interesting information was obtained. Figures 3 and 5 show the difference spectra between young and old cultures and between non-adapted and dark-adapted cells respectively, while Figures 2 and 4 give the actual absorption spectra. It will be seen that there is a general similarity between the difference spectra of reacting and non-reacting cells, no matter whether reactivity results from age or from dark-adaptation. Particularly noticeable is an increase of absorption around 480 mμ and a decrease at about 650 mμ and 460 mμ. The changes at 480 mμ might be related to changes in the carotenoid contents of the cells.

These changes were absent in old cells which do not show a change in phototactic behaviour even after being kept in the dark. Since these cells also show maximum tactic movement in light absorbed in the region of the carotenoids, a connection between the changes at 480 mμ and phototaxis seems at any rate not unlikely. However, the implication of the changes at 650 mμ and at 460 mμ is less clear.

Summary

The effects of various factors on the phototaxis of *Chlamydomonas snowiae* were studied, and an attempt was made to find a connection between phototaxis and metabolism.

Growing the algae with constant shaking, use of young cultures, previous treatment with darkness, and substances accumulating in the growth medium were all found to strengthen the phototactic reaction.

Metabolic inhibitors as well as ATP and CO_2 were found to stop phototaxis by stopping motility.

No simple connection between respiration and phototaxis could be found.

Darkness and age of culture cause a similar change in the pigment system of the cells, and it is possible that this change is connected with the change in phototaxis.

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Batophora from Central New Mexico

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In the spring of 1957 several small tufts of submerged green plants were collected from stones, brush, and other debris in one of the sinkhole ponds at Bottomless Lakes State Park east of Roswell in Chaves County, New Mexico. Unfortunately, the collection was lost before it could be identified, but three years later the plants were still present in several of the lakes. At that time they were identified as *Batophora oerstedii* J. AGARDH, a tropical marine and brackish-water green alga. Herbarium specimens have been deposited at the Universities of California (Berkeley), Michigan, Oregon, and Florida.

The genus *Batophora*, a member of the Dasycladaceae, is of common occurrence at a number of stations along the Gulf of Mexico, in the Caribbean, and at Bermuda (KOSTER, 1943; TAYLOR, 1960). The single species is found in a variety of habitats along the coast both in marine and brackish waters. Occasional collections have been reported from fresh-water stations (BREDER, 1934), but these have always been at most within a few miles of the coast. The stations at Roswell, New Mexico, on the other hand, are more than 500 miles from the nearest point on the Gulf of Mexico.

Several follow-up trips to the Bottomless Lakes area showed *Batophora* to be present in a number of the sinkholes within the park, but most abundant in Mirror Lake where it completely carpeted large expanses of the submerged rocky cliffs that enclose the lake. The plants were most abundant from the water-line to a depth of 3–5 meters. Considerable basic limnological information relating to the Bottomless Lakes can be found in the report of NAVARRE (1959). In this report *B. oerstedii* has been incorrectly listed as *Chaetophora incrassata*.

More recently *Batophora* also has been found in a second series of ponds known locally as the Lake St. Francis Pot Holes. The latter, approximately twelve in number, are located on the Bitter Lake National Wildlife Refuge, across the Pecos River and fifteen miles north of Bottomless Lakes. The development of *Batophora* in Lake St. Francis and the surrounding potholes is still more extensive than in the Bottomless Lakes. A comparison of plants from the two localities in New Mexico with a third group collected by the author in mangrove thickets near Progreso, Yucatán, showed no consistent morphological differences.

It is probable that *Batophora* has been in the Roswell area for some time. NETTLETON as early as 1892 mentioned "a thick growth of dark green moss" at the bottom of the sinkhole today known as Mirror Lake. The reference probably was to *Batophora*. Although other plants occur in this lake, *Batophora* is the only one that normally would be dark green at that time of year (February). At the present time *Batophora* seems well adapted to the environment and in no immediate danger of extinction. During the warmer months, the plants spread rapidly and colonize a variety of substrata, including bottles, tin cans, and other debris tossed into the lakes by visitors to the park. Fertile specimens bearing numerous gametangia can be collected at both locations throughout the warmer months.

The ponds of the two series are similar in general appearance. Most are typical sinkholes, ponds that have resulted from the solution and subsequent collapse of the underlying gypsum beds. The sides are steep to perpendicular. Numerous rocky ledges can be seen jutting out into the extremely clear water that extends to maximum depths of 10–30 meters. The majority of the lakes have a surface area somewhere between 1.0 and 7.5 hectares, although the largest is slightly in excess of sixty.Temperature data for the Bottomless Lakes (NAVARRE, 1959) indicate normal summer thermoclines in most of the lakes. No evidence of any meromictic condition has been found. According to park and refuge personnel, a complete ice cover seldom forms over the ponds of either series. Between December and March water temperature at the surface of the lakes remains between 1–10°C.

The water from both series of ponds is brackish. The few plants, aside from *Batophora*, that occur in the ponds are halophytes usually associated with saline marshes and coastal areas. *Ruppia maritima* L. is present in most of the Bottomless Lakes. *Triglochin maritima* L. grows about the margins of the potholes at Bitter Lake. *Chara aspera* DETH. ex WILLD. and *C. hornemannii* WALLM. are present in many of the ponds at both locations. Other than an extensive growth of epiphytic diatoms during the colder months, only small quantities of phytoplankton and mat-forming algae were encountered in the lakes.

Chemical data from the two series of ponds in which *Batophora* has been found were included in an extensive report on the ground water of Chaves County, New Mexico, recently published by Hood, Mower, and Grogin (1960). The water supply for both series of ponds is discharged from the Chalk Bluff Formation. Water from this particular formation is saline with particularly high concentrations of calcium and sulfate. A comparison of the major ion concentrations found in Mirror Lake (Bottomless Lakes), Lake St. Francis (Bitter Lake), Lake Forsyth (an oceanic fresh-water lake from which *Batophora* previously has been reported), and sea water is given in Table 1.

Table 1. A comparison of the major ion concentrations (p.p.m.) in four localities from which *Batophora* has been collected

	Mirror Lake[1]	St. Francis Lake[1]	Lake Forsyth[2]	Sea water[3]
Na	3,107(4)	2,410(4)	463	10,556
K			58	380
Ca	957	1,050	45	400
Mg	381	366	2	1,272
Cl	4,858	3,800	507	18,980
SO_4	3,960	3,770	348	2,649
HCO_3	122	92	–	140
Dissolved solids	13,275	11,400	1,452	34,482

In view of the salinity, transparency, and morphometry of the sinkhole basins and the wide ecological amplitude of *Batophora* it is not particularly surprising that this species would flourish in these lakes. On the submerged gypsum cliffs the plants occupy what otherwise would be an essentially unoccupied ecological niche. The question of dispersal, on the other hand, presents a more difficult problem. In all probability the plant was introduced by migratory water birds from somewhere along the Gulf of Mexico. The shortest possible distance over which this transfer could be effected is approximately 550 miles, but in the absence of any other known intermediate locations, a more circuitous route via the Rio Grande and Pecos River seems more reasonable. Simple experiments indicate that *Batophora* can withstand long periods in fresh water, but neither the vegetative plant nor the gametangia are very resistant to desiccation.

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[1] Data from Hood, Mower, & Grogin (1960) obtained between 1939 and 1945. Average of four determinations.

[2] Data from Breder (1934).

[3] Data from Sverdrup, Johnson, and Fleming (1942).

[4] Combined figures for sodium and potassium, separate analyses not being available for these two lakes.

Batophora has yet to be found in any other inland body of water in the region although a number of brackish or alkali lakes in Texas, New Mexico, and the adjoining Mexican states of Coahuila and Chihuahua have been examined. It seems probable that a combination of factors including rapidly fluctuating water levels, unstable muddy bottoms, and occasional strong wave action would soon eliminate *Batophora* from most of these lakes even if it were deliberately introduced into water with a suitable ion balance.

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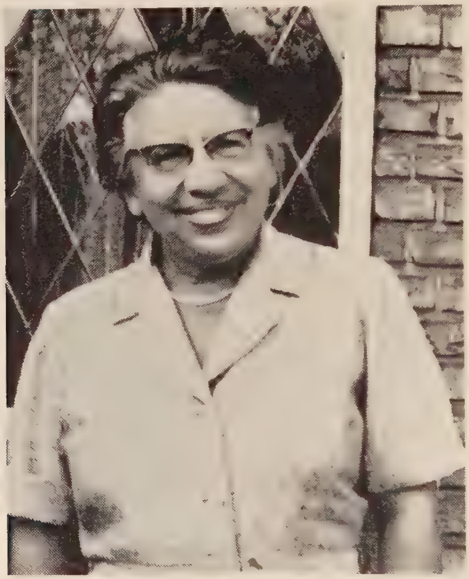

Marie Françoise Emilie Nicolai
(1900–1961)

None of the members of the Koninklijke Nederlandse Botanische Vereniging attending Dr. EMY NICOLAI's lecture on the 11th of February 1961, in which she unfolded her projects for the three-year old Hydrobiologisch Instituut at Nieuwersluis (Netherlands), would have thought that about one month later she would leave us forever.

MARIE FRANÇOISE EMILIE NICOLAI was born on the 27th of June 1900 at the Hague ('s-Gravenhage). She finished her secondary education there in 1918. The stimulating lessons on botany and zoology by Dr. A. SCHIERBEEK must have greatly influenced her choice to study biology. She went to the University at Leiden, where she took her doctor's degree in 1929.

She was an assistant to the Botanical Department of Leiden University from 1922 to 1929 and the leading assistant from 1929 to 1945. Dr. J. M. JANSE was the director of that institute up to 1930. His work in marine algae stimulated Dr. NICOLAI's interest in seaweeds. During that period she also studied the anatomy of roots of alpine plants with Dr. P. JACCARD in Zürich (May–October 1926). During September 1930 to January 1931 she was the acting director of the Botanical Department of Leiden

University, and at the same time she gave some lectures for students until Dr. L. G. M. BAAS BECKING, the succeeding director, arrived from California in 1931. This dynamic and able botanist raised in Dr. NICOLAI a profound interest in hydrobiology. In connection with some samples from Californian brines collected by Dr. BAAS BECKING, she went deeply into the vegetation of such habitats. During May to November 1937 she again visited Zürich, this time to train herself for thorough investigations of the fine structure of plant cell walls by means of polarisation and X-ray microscopy under the direction of Dr. A. FREY-WYSSLING.

From 1942 to 1947 she held a position on the Vezelinstituut T.N.O. at Delft, changing her interest from scientific to applied botany. She studied the technique of preparing transverse sections of fibres and produced a very useful and clear paper on that subject. She finished her career there when invited by Dr. R. D. PRESTON of the University of Leeds (Great Britain) to join him in his investigations of the fine structure of cell walls.

In 1948 she was appointed a botanist in the Department of Botany of the University of Leeds, where in collaboration with Dr. PRESTON she continued her fundamental and well-known investigations of chlorophycean cell walls. She also was the leader of several practical botanical courses. In 1955 she visited Bogor (Java), where her best friend, Dr. JAKOBA RUINEN, was the director of the Treub Laboratorium in the Botanical Garden. Together, they traveled through Java and Bali, admiring the tender as well as imposing nature and the great monuments of art.

It is known that Dr. NICOLAI deeply enjoyed her stay in Great Britain, where so many phycological and other friends surrounded her with a warm sympathy. However, she was also very devoted to her own country, and so she moved to the Netherlands again in 1957, when she was requested to start a hydrobiological institute in that country and to become its first director. She undertook this heavy task to the best of her ability and with all her heart, starting to traverse the overcrowded country in order to find a proper building in which to establish the institute. She could lay hands on a country-house along the river Vecht. The hydrobiological institute is meant for experimental fresh-water ecology and, moreover, for the training of students in this field of science.

Dr. NICOLAI's many friends in the Netherlands, Great Britain, Switzerland, and France were deeply shocked by her sudden death resulting from a cerebral hemorrhage on the 13th of March 1961. Now that her task is finished before she expected, it is left to others to carry out her projects, such as a study of bacterial influence in fresh waters. – J. TH. KOSTER, Rijksherbarium, Leiden, Netherlands.

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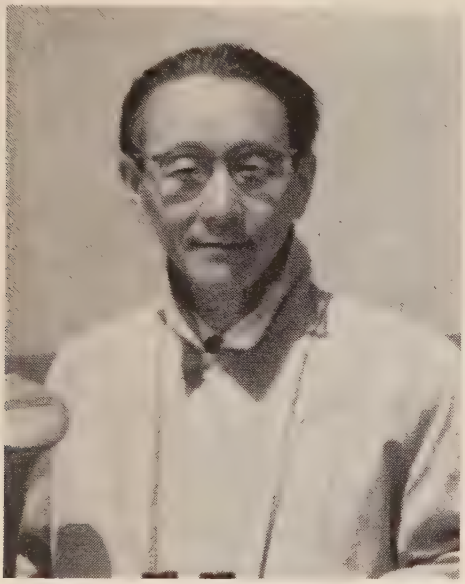

Sokichi Segawa
(1904–1960)

SOKICHI SEGAWA, professor of marine botany at the Fisheries Laboratory of Kyushu University, died on November 4, 1960, at the age of fifty-six, after he had been suddenly stricken with a cerebral hemorrhage at the annual meeting of the Japanese Society of Phycology held on November 3 in Osaka. With his death Japan lost one of the most active leaders in phycology.

Prof. SEGAWA was born in 1904 at Morioka, where he passed his boyhood, youth, and college days. His interest in botany from boyhood was influenced by his sister and brother. After graduation from the Morioka Imperial College of Agriculture and Forestry in 1927, he taught for three years at the high school near his home town, and later he entered the Hokkaido Imperial University, where he read phycology under Prof. YUKIO YAMADA, taking up the taxonomic study of the corallinaceous algae in his final course.

After being graduated, he came to the Mitsui Institute of Marine Biology (located at Susaki near Shimoda, Izu Peninsula) as a researcher.

Three years later, in 1937, he joined the staff of the Institute and served there until he was appointed Assistant Professor at Kyushu University in 1942. It may safely be said that the groundwork of his academic career as phycologist was mainly fostered in this period. During these years he devoted himself to studies on marine algae from taxonomic and ecological points of view. He made extensive algal collections throughout Japan and its vicinity, including Saghalien, Formosa, Loochoo, and Bonin Islands, and energetic ecological examinations of marine vegetation as well as morphological and anatomical observations on a large number of algae that he himself had collected.

His lifelong work, "Systematic anatomy of the corallinaceous algae," consisted of two parts: (1) "Systematic anatomy of the articulated corallines"; and (2) "Systematic anatomy of the crustaceous corallines". The first part, comprising a long series of articles, formed the dissertation of his doctoral degree in 1948 and was successively published in the *Journal of Japanese Botany*, *Seibutsu*, and the *Botanical Magazine* (*Tokyo*). In this work he paid much attention to the relation of the anatomical characters of the algae to their systematic position and he also established a new genus, *Yamadaia*. The second part, in which more than 40 species of Melobesioideae (including more than 10 new species) were expected to be dealt with, was almost completed, but it was yet unpublished because Prof. SEGAWA desired to publish it only after having examined closely the related specimens preserved in the herbarium of M. FOSLIE in Norway. It is a serious loss to the world of phycology.

Prof. SEGAWA was Assistant Professor at Kyushu University from 1942 to 1960 and became Professor on November 1, 1960. At various times he served as part-time professor or instructor at Nagasaki University, Kumamoto University, Miyazaki University, Toyama University, and the Fisheries College, and was also Visiting Professor at the University of the Ryukyus. He devoted himself to the Japanese Society of Phycology, the Japanese Society of Scientific Fisheries and the Botanical Society of Japan, for many years as a councilor, and for the last several years he was continuously elected Manager of the Kyushu Branch of the last-mentioned society. He was also a member of the Subcommittee on Algae of the Standing Committee on Pacific Botany of the Pacific Science Association since 1958. In addition to providing scientific knowledge, he contributed his efforts markedly to education, to the administration of Kyushu University, to the progress of fisheries, especially the propagation of useful seaweeds in Japan, as well as to the promotion of the world of phycology. In 1956 he published "Coloured Illustrations of the Seaweeds of Japan," which comprises beautiful photographs showing the habits of 592 species. This will be a favorite book, not only among Japanese phycologists, but also among foreigners who want to know the outline of the marine algae of Japan. In 1957 he took up the study of the floating seaweeds, which play an important rôle in the life of certain useful fishes, and in 1959 he received the Asahi Scientific Grant from Asahi Newspaper Co. Ltd. for this work. With his students, he undertook this work with great energy on research ships throughout the coastal seas around Japan, and the project was well under way.

Indeed, Prof. Segawa's personal investigations were of great practical importance as well as of outstanding scientific interest. He was not only a man of patient and self-possessed character, but also a scientist of unlimited enthusiasm and vitality. All his friends and pupils will remember him with respect and affection.

He married, in 1937, Shizuko, daughter of the late Dr. Kintaro Okamura, the famous phycologist, and he is survived by his wife, two sons, and a daughter. – Mitsuo Chihari, Shimoda Marine Biological Station, Shimoda, Japan.

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[1] Language code: E, English; J, Japanese; JE, Japanese with English summary; JL, Japanese with Latin diagnoses.

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PHYCOLOGIA 1 (4) 1961

Nils Eberhard Svedelius: A Chapter in the History of Phycology[1]

GEORGE F. PAPENFUSS
University of California, Berkeley, U.S.A.

With the death of Professor SVEDELIUS on August 2, 1960, a few days before his 87th birthday, the world lost an eminent botanist. He was born in Stockholm on August 5, 1873, and received his doctorate at Uppsala in 1901 under the distinguished Swedish phycologist FRANS REINHOLD KJELLMAN. Except for a year on the botanical staff of the Naturhistoriska Riksmuseet in Stockholm, his entire career was spent in the service of the University of Uppsala. For a number of years he was Acting Professor and in 1914 he was appointed to the Chair of Botany formerly occupied by KJELLMAN. He retired in 1938.

SVEDELIUS's doctoral thesis (1901) was concerned with the ecology and taxonomy of the Baltic algae occurring along the coasts of the Swedish Provinces of Småland and Gotland. The year after he received his degree he made a journey to Ceylon, where for almost a year, November 1902 to August 1903, he studied the ecology of tropical littoral algae and gathered material for future morphological and taxonomic investigations. Through his Ceylon experience he acquired a life-long interest in tropical marine algae.

His first major paper on Ceylon algae was his monograph (1906b) on the ecology and taxonomy of the species of *Caulerpa* of that island. The same year (1906c) he also published a general ecological paper on the algae of a Ceylon coral reef, with particular reference to their seasonal periodicity. These two papers are still the only extensive accounts of the ecology of truly tropical algae. SVEDELIUS was the first to point out, as far as I am aware, that many tropical marine algae, like tropical land plants and the terrestrial and aquatic plants of cold and temperate regions, exhibit a periodicity in growth or reproduction or in both.

A natural outgrowth of SVEDELIUS's work on Ceylon algae was his

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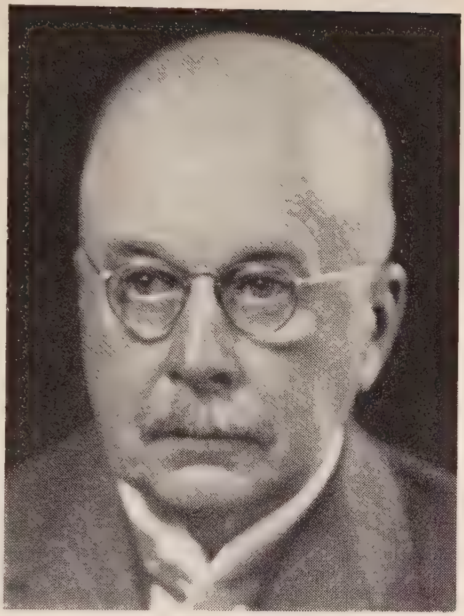
G. Sundgren phot. 1938

Nils Eberhard Svedelius
(1873–1960)

interest in the geographical distribution of tropical marine algae. It is a remarkable and seemingly anomalous fact that a fairly large number of genera and some species of algae that occur in the Caribean have a westward distribution that extends all the way to the shores of East Africa, whereas relatively few forms have an eastward distribution extending to the coast of West Africa. This discontinuity in the distribution of algae in the Atlantic, as contrasted with their more or less continuous westward distribution from the Caribean across the Pacific and Indian Oceans, is puzzling. MURRAY (Phycological memoirs, Part II, 1893), recognizing the similarity between the flora of the Caribean and that of the Indo-Pacific, postulated a migration during former epochs via the Cape of Good Hope, when the seas in that region were warmer than they are today. A simpler explanation was furnished by SVEDELIUS (1906a, 1906b, 1923c, 1924a). He drew attention to the fact that open communication between the Caribean and the Pacific had existed at a number of different times in the geologic past. Ample opportunity had thus existed for a migration of species from the Caribean to the Pacific or vice versa. Neither MURRAY nor SVEDELIUS offered an explanation of the discontinuity in the distribution of many tropical algae in the Atlantic, and to my knowledge no phycologist has discussed this question.

SVEDELIUS (1924a, p. 3) lamented the fact that taxonomically the algae were too poorly known to allow definite conclusions to be drawn about their geographic distribution. Although a good deal of additional knowledge has been acquired since the time of his writing and the floras of a number of areas have become better known, the fact remains that we are still very poorly informed on the algae of most of the world and on the characters whereby many of the currently accepted species may be distinguished from others in the same genera. It is almost as hazardous today to talk about the geographic distribution of species of algae as it was in 1924. The geographic distribution of genera can be discussed in a general way but we need critical studies of the species before it will be possible to have meaningful discussions of the distribution of species or groups of related species. The realization of this ideal is a long way off.

The specimens brought back from Ceylon provided SVEDELIUS with a wealth of material for morphological and systematic research and occupied his attention at different times throughout his career. His first major work on the red algae of Ceylon was the monograph of 1908(d) on the structure, reproduction, and taxonomy of the delesseriaceous genus *Martensia*.

Through his work on *Martensia*, SVEDELIUS acquired a lasting interest in the developmental morphology and life histories of red algae, the group in which he made his greatest contributions to the advancement of botany.

This interest was further stimulated by YAMANOUCHI's discovery in 1906 (Bot. Gaz., Vols. 41 and 42) of the occurrence of meiosis in the tetrasporangia of *Polysiphonia flexicaulis*. Previously it had been thought that these structures were merely accessory reproductive organs of the sexual plants.

SVEDELIUS' material of *Martensia*, being preserved only in formalin, was unsuitable for a study of the chromosomal cycle in this genus. For such an investigation he turned to another member of the Delesseriaceae, *Delesseria sanguinea*, of which he could obtain abundant material on the west coast of Sweden. He (1911c, 1912, 1914a) confirmed the observations of YAMANOUCHI and of LEWIS (Ann. Bot., Vol. 23, 1909), who in the meantime had published upon *Griffithsia globulifera*, that an alternation of generations existed in red algae between haploid gametophytes and diploid tetrasporophytes, with meiosis occurring in the tetrasporangia.

It was in the first of his papers on *Delesseria* that SVEDELIUS introduced his series of comprehensive discussions (1911c, 1919a, 1921a, 1927c, 1929b) of alternation of generations in plants in general and algae in particular. The opinion had been held in some quarters that it is immaterial where meiosis occurs in the life history of an organism, the only essential thing being that it should take place. SVEDELIUS (1921a, 1927c, 1929b) vigorously opposed this view and was the first biologist to point out that the place of meiosis in the life history is of greatest importance as regards the genetic variability and hence the rate of evolution of organisms. In organisms with a life history in which the zygote is the only diploid cell, one syngamy is followed by only one meiosis. Postponement of meiosis and intervening division by mitosis on the other hand results in a diploid generation and ultimately many meioses, hence a much greater number of genetically different nuclei in the subsequently produced crop of gametes. It is generally accepted today (cf. STEBBINS, Variation and evolution in plants, 1950) that diploid organisms or those with a diploid generation in their life history have a greater evolutionary potential than do haploid organisms, with the possible exception of such rapidly multiplying forms as *Chlamydomonas*.

Until SVEDELIUS studied *Martensia*, it was believed that the tetrasporangial primordia of red algae were always uninucleate. He discovered that they are multinucleate in this genus, but that all the nuclei except one degenerate. The remaining nucleus then divides to produce the four nuclei of the tetrasporangium. He (1914b) later observed the same situation in *Nitophyllum punctatum* and, with properly fixed material available, was able to determine that the functional nucleus divided meiotically to produce the four tetraspore nuclei. The spores are thus uninucleate and haploid.

It was well known to students of the red algae that some species at times bore both sexual organs and tetrasporangia on the same individual; and it was such plants that had in part been responsible for the belief that the tetrasporangia of red algae were only accessory reproductive organs of the sexual plants. SVEDELIUS (1914c) studied the cytology of the sporangia occurring on sexual plants of *Nitophyllum punctatum*. He observed that in such plants the sporangial primordia are also multinucleate and all the nuclei except one degenerate. This nucleus, however, does not undergo division, and one spore, instead of a tetrad of spores, is formed. These plants were found to be haploid. This study confirmed the observations of YAMANOUCHI and LEWIS with respect to the sporangia occurring on sexual plants of *Polysiphonia flexicaulis* and *Griffithsia globulifera*, respectively.

Largely still uninvestigated are the relatively many cases of red algae in which sexual organs and sporangia with their contents divided into four spores occur on the same plant. One such case, *Spermothamnion turneri*, was investigated by DREW (Ann. Bot. Vol. 48, 1934, and ser. 2, Vol. 7, 1943) who found that these plants are diploid. Contrary to the assumption that cystocarps on such diploid plants would be produced without a preceding fertilization, DREW showed that the diploid carpogonia are fertilized, by either a haploid or a diploid spermatium. If fertilization is effected by a diploid spermatium, the ensuing tetraploid carpospores apparently are not viable, as tetraploid plants are never encountered in nature. If fertilization is effected by haploid spermatia, viable triploid carpospores are formed but the ensuing triploid plants seem to remain sterile.

Svedelius (1935a, 1935b, 1937) later studied *Lomentaria rosea*, which in Europe produces only tetrasporangia. He found that meiosis does not occur in the tetrasporangium and the spores have the same chromosome number as the parent plant. Upon germination the spores give rise to other, presumably diploid, tetrasporophytes. In Europe, therefore, *L. rosea* appears to have lost the sexual generation through the suppression of meiosis.

It had been known for a long time that in many Florideophycidae, especially members of the order Nemalionales, tetrasporangia were never produced. Having satisfied himself by personal studies upon *Delesseria sanguinea* and *Nitophyllum punctatum* of the correctness of Yamanouchi's and Lewis's observations in regard to the nuclear cycle in tetrasporangium-bearing red algae, Svedelius turned his attention to red algae of this other type. He selected as a plant for investigation *Scinaia furcellata*, a member of the family Chaetangiaceae of the Nemalionales, and in 1915 published his now classical paper on this alga. He established that in *S. furcellata* meiosis occurs immediately after fertilization. Three of the nuclei degenerate and the functional nucleus immediately initiates the gonimoblast. Svedelius proposed the terms haplobiontic and diplobiontic to denote the two major types of life histories in the algae, haplobiontic denoting the type with one vegetative generation (haploid or diploid) and diplobiontic denoting the type with two independent, alternating generations. These terms are in general use today, but were frequently confused in the past with the designations haplont (haploid organism) and diplont (diploid organism), much to Svedelius's displeasure.

Svedelius observed that in *Scinaia* the zygote nucleus migrates from the carpogonium into the hypogynous cell within which meiosis occurs. A protuberance is then formed by the cytoplasm of the hypogynous cell which grows into and through the carpogonium and initiates the gonimoblast. He therefore considered the hypogynous cell of *Scinaia* to perform the rôle of generative auxiliary cell. Kylin, however, maintained that the hypogynous cell was merely a nutritive cell and in his opinion *Scinaia*, like other Nemalionales, could not be considered as possessing a generative auxiliary cell.

Svedelius returned to this question in 1933(b) in a significant paper on the development of *Asparagopsis armata* and *Bonnemaisonia aspara-*

goides. Neither of these genera was known to possess free-living tetrasporophytes. He established that in *Asparagopsis* the zygote nucleus migrates into the hypogynous cell, where meiosis takes place. Two of the four nuclei degenerate and the other two function in the production of the gonimoblast, two or more gonimolobes being formed. A significant feature is that in *Asparagopsis* the gonimoblast issues directly from the hypogynous cell. In the closely related *Bonnemaisonia*, on the other hand, the zygote nucleus remains in the carpogonium. Meiosis occurs there and the gonimoblast is initiated by the carpogonium.

SVEDELIUS emphasized that in *Asparagopsis* the hypogynous cell met all the requirements of a generative auxiliary cell, even in the qualified sense of KYLIN (Lunds Univ. Årsskr., ser. 2, Avd. 2, Vol. 26(6), 1930; Bot. Rev., Vol. 1, 1935; K. Fysiogr. Sällsk. Lund Förhandl., Vol. 14(20), 1944), who restricted the concept of auxiliary cell to those cells which receive a diploid nucleus from the carpogonium and ultimately produce the gonimoblast. In the opinion of SVEDELIUS it was incorrect, therefore, to regard all Nemalionales as lacking generative auxiliary cells. He also maintained that in *Scinaia* the hypogynous cell should be considered a generative auxiliary cell, even though the gonimoblast seemingly issued from the carpogonium.

In 1939 MARTIN (Journ. Linn. Soc. Bot., Vol. 52) observed that in *Chaetangium*, the type genus of the Chaetangiaceae, the hypogynous cell also serves as the starting point of the gonimoblast, and she agreed with SVEDELIUS that this cell should be considered a typical (generative) auxiliary cell.

Shortly afterward, it was established by SVEDELIUS (1941, 1942a, 1942b) in a detailed study of several South African species of *Galaxaura*, another member of the Chaetangiaceae, that also in this genus the zygote nucleus migrates into the hypogynous cell. The nucleus then divides mitotically a number of times, some of the daughter nuclei migrate into the basal cell of the three-celled carpogonial branch while some migrate into the carpogonium, and gonimolobes are initiated by all three cells. (It will be recalled that *Galaxaura* is diplobiontic, meiosis occurring in the tetrasporangia of the tetrasporophytes.)

The question of whether those Nemalionales in which meiosis occurs immediately after fertilization are primitive or, as FELDMANN (Rev. Cytol. Biol. Vég., Vol. 13, 1952) has contended, reduced, was discussed by SVEDELIUS in an excellent short paper (his last) in 1956. He furnished convincing evidence in support of the long held belief that these algae are truly primitive.

J. and G. Feldmann (Ann. Sc. Nat. Bot., ser. 11, Vol. 3, 1942) have obtained results which indicate that *Hymenoclonium serpens* and *Falkenbergia rufolanosa* represent filamentous tetrasporangial stages in the life histories of *Bonnemaisonia asparagoides* and *Asparagopsis armata*, respectively, and that *Trailliella intricata* probably represents a filamentous tetrasporangial stage in the life history of *Bonnemaisonia hamifera*. That a relationship actually exists between *T. intricata* and *B. hamifera* was later demonstrated by Koch (Archiv Mikrobiol., Vol. 14, 1950). *Bonnemaisonia* and *Asparagopsis* thus display a triphasic life history in which the free-living tetrasporophyte is morphologically very different from the gametophyte. The cytology of these filamentous tetrasporophytes has not yet been investigated, but in view of Svedelius's observations that meiosis occurs immediately after fertilization in *Asparagopsis* and *Bonnemaisonia*, it must be supposed that the tetrasporophytes are haploid, and Koch's cultural work has given indirect evidence that *Trailliella* actually is haploid. However, the whole problem calls for further cultural and cytological study.

On the basis of the unusual life histories of *Bonnemaisonia* and *Asparagopsis*, the Feldmanns in 1942 removed the family Bonnemaisoniaceae from the Nemalionales to a new order Bonnemaisoniales. This order has not received general acceptance because it seemed doubtful that all Bonnemaisoniaceae would be found to have this kind of life history. In a recent paper, Fan (Univ. Calif. Publ. Bot., Vol. 32, 1961) has accepted the Bonnemaisoniales. As the main distinguishing character of the order, however, he has recognized the feature discovered by Svedelius, namely, that the hypogynous cell functions as a generative auxiliary cell. For the same reason he has also removed the Chaetangiaceae from the Nemalionales to the Bonnemaisoniales.

Svedelius was especially active in the affairs of the University of Uppsala and played a leading rôle in Swedish and international scientific societies. He was Sweden's representative to the Fourth (Ithaca), Fifth (Cambridge), and Sixth (Amsterdam) International Botanical Congresses, and was President of the Botanical Section of the International Biological Union from 1935 to 1950.

In 1922 he was made a Knight, in 1934 a Commander and in 1947 a Knight Commander of the Royal Swedish Order of the Polar Star. The importance of his contributions to the advancement of science was abundantly recognized at home and abroad by election to membership in a large number of learned societies, including the Royal Swedish Academy of Sciences, the Royal Society (London), the Finnish Society of Sciences, and the Bohemian Society of Sciences in Prague. In 1952 he became an Honorary Member of the Royal Society of Sciences in Uppsala.

SVEDELIUS's research was not confined to the algae but included, especially during his early professional life, work on a number of genera of flowering plants. A stimulating feature of his publications is his attention to detail and the breadth of his comparisons and discussions. His major papers, especially those on alternation of generations, may well serve as prescribed reading in courses on the algae. With his death a significant chapter in the history of phycology has come to a close.

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1901. Studier öfver Östersjöns hafsalgflora. Akademisk afhandling. Upsala. [4] + 140 pp., 26 figs.

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1906a. Om likheten mellan Västindiens samt Indiska och Stilla Oceanens marina vegetation. *Ibid.* 1906: 49–57.

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1911a. Rhodophyceae. *In* A. Engler & K. Prantl (ed.), Die natürlichen Pflanzenfamilien ... Nachträge zu I. Teil, Abteilung 2. Leipzig. Pp. 189–276, figs. 104–170.

— b. *Erythrocladia irregularis* Rosenv., en för Sverige icke förut anmärkt floridé. Svensk Bot. Tidskr. 5: 217–218.

— c. Über den Generationswechsel bei *Delesseria sanguinea*. *Ibid.* 5: 260–324, pls. 2 & 3, 16 text-figs.

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— b. Über die Tetradenteilung in den vielkernigen Tetrasporangiumanlagen bei *Nitophyllum punctatum*. Ber. Deutsch. Bot. Ges. 32: 48–57, pl. 1, 1 text-fig.

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Phycological Activity in Czechoslovakia

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Czechoslovakia, especially its western territory Bohemia, is a classic land of inland waters phycological research. The investigations of algae in CORDA (1834) are based on material from Bohemia, descriptions of thermal blue-green algae originate from Bohemian spas (C. A. AGARDH, 1834), and diatomaceous earths were collected and studied in the surroundings of Františkovy lázně (EHRENBERG, 1837; KÜTZING, 1844). STEIN's fundamental work on flagellates (1878) and that of LEONHARDI (1863) on Charales were also based on materials from Bohemia. The state of phycological research in Bohemia in the last decade of the last century is shown in HANSGIRG's Prodromus of the Czech Algae (1889–1892). He mentions 1695 (or according to RABENHORST's classification, 2214) species of algae and flagellates, except diatoms and Charales, found in this rather small territory.

The monograph of Bohemian Charales was written by VILHELM (1914) and a list of Bohemian diatoms was compiled by PROCHÁZKA (1924). HANSGIRG's Prodromus deals mainly with large species of algae, living in benthos, prepared often by herbarium technique. Flagellates, Xanthophyceae, planctonic species, and those small algae in benthos which need to be studied in living state are scarcely represented. The investigation of these algae is the meritorious work of PASCHER who in the years 1903–1945 described and studied several hundred species of algae in Bohemia which were later also discovered in other parts of the world. The first experiments on cultivation of blue-green algae isolated from lichens were carried out by UHLÍŘ (1913) and from lime incrustations by PRÁT (1925). PRINGSHEIM (1928) based his collection of pure cultures on Bohemian material. This collection is being kept not only in Prague, but also in the main collections of algal cultures in the world.

Phycological research in Czechoslovakia thus has an old tradition. The richness of its algal flora is afforded by the vertical diversity of territory from lowlands up to the highest mountains and by the variety of geological substrata. Before World War II, seven Czech botanists were engaged in phycological research. At the present time 31 members comprise the Algology Section; the majority of them have completed their studies after the war and were trained in algology at the Charles University Botanical Institute under the leadership of Prof. Fott. As an aid for university students a textbook on algology was published by Fott at first in Czech (Sinice a řasy, 1956) and later in German (Algenkunde, 1959). In contrast to the textbooks previously used, this work is written from the point of view of taxonomy of algae. The book takes account mainly of fresh-water algae, selected in order to represent and illustrate the most typical and frequent species occurring in Central Europe.

The Algology Section of the Czechoslovak Botanical Society was established in 1955 and soon became the organising centre of phycological research. Floristic and taxonomic research is considered to be of fundamental importance, as only those physiological experiments and biochemical investigations which have been carried out with taxonomically well known material of algae lead to reliable results. Likewise, hydrobiological research and agricultural experiments cannot be successful unless they are based on the results of taxonomic study of algae.

The Algology Section organises regional research. Thus the phycologically interesting areas are explored by experts on various groups of algae; small and tender species are studied directly in the field while others are fixed for later study. In this way various pond-areas were explored in Bohemia, and similar attention has been paid to the Šumava peat-waters, the High Tatras, the Orava peats, etc. There are many ponds in Bohemia and Moravia used for the breeding of carp; they originated in the 16th century and were situated in moorland infertile swamps. In these ponds, as a result of inorganic fertilizing, impressive water-blooms of blue-greens arise, and in addition coccoid green algae thrive there. For this reason numerous taxonomic and ecological studies have been devoted to coccoid green algae (Fott: *Siderocelis*, *Quadricoccus*, *Lagerheimia*, *Chodatella*, *Ankyra*, etc.). Komárek's work (1958) deals with the revision of blue-green algae which form water-blooms in ponds (*Anabaena*, *Microcystis*, *Aphanizomenon*, *Gloeotrichia*, etc.). He reduced certain taxa to synonymy and brought to use and emended the original correct descriptions. Basic research of Volvocales and Tetrasporales had been done before World War II by Pascher (1927). Ettl (*Chlamydomonas*, *Chlorogonium*, *Carteria*, *Chlorangium*) and Fott (*Corone*) described new species and introduced new conceptions of genera. Růžička verified some species of desmids generally considered as widespread but inaccurately defined and completed the taxonomy of desmids by new descriptions (mainly from the genera *Closterium* and *Cosmarium*). He tried to delimit the lower taxa so that they could be a valid aid in taxonomy and excluded many unjustified taxa. He described communities of desmids in the upper river streams. ROSA investigated the desmids of South Bohemia and the species thriving in soils. MARVAN and BÍLÝ are carrying out research on diatoms in Moravia and the High Tatras. ŘEHÁKOVÁ is beginning to study fossil diatoms. TOMAN and FOTT have published their investigations on the submicroscopic structure of diatom cell walls based on photographs obtained with an electron microscope.

In the research of chrysomonads (FOTT, JURIŠ, MARVAN) observations of sexuality in Ochromonadales have been complemented and summarized; in the taxonomy of *Synura* and *Mallomonas*, the submicroscopic structure of scales was used as a differential characteristic. Bohemia is a classic land for research in Xanthophyceae, because most of the material for PASCHER's basic monograph (1939) originated from this country. Coccoid Xanthophyceae were studied, especially those that are convergent to green algae of the genera *Tetraedron* and *Characium*, as well as the filamentous species (ETTL, FOTT, KOMÁREK). There are several occasional observations on Euglenales, Chloromonadales, Dinococcales and Salpingoecales, bringing new descriptions and completing old ones (ETTL, FOTT, JAVORNICKÝ, PERMAN, POPOVSKÝ).

Research in ecology is often joined with taxonomic studies. The construction of dams on rivers stimulated the research of phytoplankton (ETTL, FOTT, JAVORNICKÝ, KOMÁREK, MARVAN) as well as benthos in the littoral and on object-slides (SLÁDEČKOVÁ). The importance of benthos of algae for fishery (HETEŠA) and for technological quality of water (SLÁDEČKOVÁ) is undeniable, but it is necessary to qualify the degree of its value. Maps on pollution of rivers were worked out (Z. and B. CYRUS, HANUŠKA), based on the algal communities, and the system of algal indicators has been revised (FOTT). The first results on the composition of communities of soil-algae were gained especially from forest soils (ROSA). In physiological research of algae, PRÁT investigated the influence of algae on the formation of travertine, the effect of benzidin, polyphenol and Schiff's reagent on the protoplast and nucleus of algae, the importance of blue-green algae in thermal waters and curative muds, their behaviour at ultra-low temperatures, etc. The Biological Institute of the Czechoslovak Academy of Sciences keeps an extensive culture collection of algae and autotrophic organisms (PRÁT) and provides material for algological work of all kinds. The effects of growth and humic substances on algae were examined by LHOTSKÝ; DVOŘÁKOVÁ dealt with the conditions of growth of algae in cultures. In 1960 the Laboratory for Research of algae was established by the Czechoslovak Academy of Sciences in Třeboň. Its main task is to study photosynthesis and the physiology of algae in mass cultures as well as the development of plants for large scale cultivation (ŠETLÍK).

In the future Czechoslovak algologists intend to carry on systematic studies of all kinds of biotopes in order to complete taxonomic survey and to investigate the hitherto imperfectly known groups of algae. They believe that knowledge of ecology and physiology can be very useful in the economic application of algae, as in fisheries, water supplies, water pollution, etc. Finally, they intend to select those species of algae which will prove to be the most productive for mass culture and by the selection of clones to insure maximum yields in this new branch of agriculture.

Manuscript received March 14, 1961.

International Phycological Society

Meeting of the Council[1]

Casino Municipal, Biarritz, France, Sept. 20, 1961

Present: Dr. J. FELDMANN (president), Dr. J. TH. KOSTER (secretary), Dr. J. GERLOFF (treasurer), Dr. T. BRAARUD.

It was felt unanimously that an American should join the Council, as nearly half of the members of the Society are Americans. Both Dr. FELDMANN and Dr. BRAARUD, whose terms together with that of Dr. FOGG expire Dec. 31, 1961, offered to be replaced by an American. As a large number of French phycologists have joined the Society, Dr. FELDMANN was persuaded to offer himself for re-election.

The president expressed deep disappointment that there will be no phycological section of the 10th International Botanical Congress in Edinburgh, August 1964. The papers on phycology will be dispersed over several symposia. At Stockholm (1950) the disadvantages of this system were obvious, and in Paris (1954) for the first time a phycological section was started, which was a great success. At Montreal (1959) the phycological section was maintained. The Council decided to ask the general meeting to send a protest to Dr. H. GODWIN, president of the Organizing Committee of the Edinburgh congress.

Meeting of the Council with the Council of the International Seaweed Symposium

Casino Municipal, Biarritz, France, Sept. 21, 1961

Present: Dr. J. FELDMANN, Dr. J. TH. KOSTER, Dr. J. GERLOFF, Dr. T. BRAARUD, Dr. F. N. WOODWARD, Dr. E. G. YOUNG, Dr. T. DILLON.

It was announced that the 5th International Seaweed Symposium will be held in Halifax, Nova Scotia, August or September 1964. Only papers on chemistry, biochemistry, and utilization will be admitted. The Council of the Symposium wants to keep its independent state, but would like to cooperate with the International Phycological Society, which proposes to combine a meeting with the Symposium. Dr. YOUNG raised the question of the difficulty of lodging such a large number of participants in Halifax.

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[1] The minutes of these meetings have been abstracted and edited for purposes of publication. – Editor.

Meeting of the Council with members of the councils of various national phycological societies and with Dr. M. Ruivo, Chief, Program Research Section, Fisheries Division, Biology Branch, F.A.O.

Casino Municipal, Biarritz, France, Sept. 22, 1961

Present: Dr. J. Feldmann, Dr. J. Th. Koster, Dr. T. Braarud (I.P.S.); Dr. E. Conway, Dr. M. T. Martin, Dr. P. S. Dixon (British Phycological Society); Dr. T. Tanaka (Japanese Society of Phycology); Dr. L. Provasoli, Dr. R. C. Starr (Phycological Society of America); Dr. A. Davy de Virville (Société phycologique de France); Dr. M. Ruivo (F.A.O.).

The main subject of this meeting was the annual phycological bibliography. The president asked the national phycological societies to cooperate. This matter will be pursued in meetings of the respective councils and the results will be published in Phycologia. Dr. Ruivo showed a volume of "Current bibliography for aquatic sciences and fisheries," edited by F.A.O. He expressed willingness to cooperate with the International Phycological Society and offered to lift the references about algae from this list for use in Dr. Silva's list. The president suggested that Dr. Silva arrange cooperation with F.A.O.

Dr. Ruivo showed a zoological monograph of the type desired by F.A.O. He encouraged phycologists to prepare monographs on algae in the same way and promised collaboration.

The lack of a phycological section for the Edinburgh congress was discussed. Dr. Dixon mentioned that special morning and evening sessions will be reserved for papers on phycology.

First General Meeting

Casino Municipal, Biarritz, France, Sept. 23, 1961

Members of Council present: Dr. J. Feldmann (president), Dr. J. Th. Koster (secretary), Dr. J. Gerloff (treasurer), Dr. T. Braarud.

About 50 members and visitors were present. The president read a salutation from the president of the Japanese Society of Phycology to the meeting. He also welcomed the councils of the national phycological societies and read a letter from Dr. Silva expressing regret at not being able to attend the meeting. The president stated that Dr. Silva, being the founder of the Society and having done so much for the young organization, is due our profound thanks. A message was sent to him from the meeting.

Report of Organizing Committee

Membership Data

The International Phycological Society was founded Jan. 1, 1961. As of Sept. 23, 1961, there were 380 individual members from 41 countries: U.S.A. 164 members, Japan 43, France 25, U.K. 24, Germany 14, Canada, Denmark 11 each, India 10, Netherlands 8, Argentina 7, Sweden 6, Czechoslovakia 5, Philippines, South Africa 4 each, Hungary, Ireland, Israel, Italy, Switzerland 3 each, Australia, Austria, Finland, Malaya, New Zealand, Portugal, Yugoslavia 2 each, Belgium, Brazil, Chile, Egypt, Ghana, Greece, Hongkong, Kenya, Morocco, Norway, Pakistan, Southern Rhodesia, Spain, U. S. S. R., Vietnam 1 each. Thus, the continents were represented as follows: North America 175 members, Europe 118, Asia 65, Africa 9, South America 9, and Australia–New Zealand 4.

There were two deaths during the year: Marie Françoise Emilie Nicolai, Director, Hydrobiologisch Instituut, Nieuwersluis, Netherlands; died March 13, 1961. Robert Brian Gordon, Research Assistant to Professor Papenfuss, University of California, Berkeley; killed in airplane crash, Sept. 1, 1961.

As of Sept. 23, 1961, there were 17 institutional members. The campaign for institutional memberships and library subscriptions has just begun.

Organization

To facilitate the initial functioning of the Society, the Organizing Committee agreed to serve as the first Executive Council. The Council elected officers for 1961 as follows: J. FELDMANN, president; J. TH. KOSTER, secretary; and J. GERLOFF, treasurer. As soon as practicable, duties and business of the secretary and treasurer now transacted by the Berkeley office of the Society will be transferred to the proper officer.

Phycologia

P. C. SILVA, Editor; T. CHRISTENSEN, Assistant Editor. The annual phycological bibliography for 1959 comprises more than 1,700 references. A reprint of this list, printed on only one side of each sheet, may be purchased for $ 1.00 from Mr. CHRISTENSEN. Vol. 1, no. 4, will appear during the final quarter of 1961 and will contain various types of contributions.

Forthcoming Meetings

On recommendation of the Council, the International Phycological Society will meet in conjunction with the 15th International Congress of Limnology (Madison, Wisconsin, Aug. 19–25, 1962), the 5th International Seaweed Symposium (Halifax, Nova Scotia, August or September 1964), and the 10th International Botanical Congress (Edinburgh, August 1964). There will be no phycological section of the Edinburgh congress. Protests to Dr. FOGG, secretary of the Organizing Committee, have been sent by Dr. FELDMANN in the name of the Society, by Dr. DAVY DE VIRVILLE on behalf of the Société phycologique de France, and by Dr. MYERS on behalf of the Phycological Society of America. The president asked the meeting whether they wished to send a protest to Dr. H. GODWIN, the president of the Organizing Committee of the Edinburgh congress. After some discussion a vote was taken. On the ballot 35 members favored sending the protest and 4 opposed it. According to a proposal of Dr. CLENDENNING, additional cooperation will be offered with the protest.

As the 5th International Seaweed Symposium in Halifax will take only papers on utilization, chemistry, and biochemistry, the president proposed a joint meeting of the Society to provide an opportunity for papers on "useless" algae.

Annual Phycological Bibliography

The president pointed out the importance of the bibliography and stated that a meeting of the Council with members of the councils of the national phycological societies and with Dr. RUIVO of the F.A.O. had been held to discuss that subject [cf. Council Meeting above]. Dr. RUIVO, after giving best wishes to the Society from the F.A.O., stated that the F.A.O. wants to cooperate in all matters that concern food. In Rome a staff for bibliography is working in cooperation with the Rhode Island Centre. Dr. RUIVO also stressed the need for monographs on algae. The F.A.O. has much interest in this type of work.

Comprehensive Phycological Bibliography

In a memorandum addressed to the Council, Dr. SILVA has written about a comprehensive phycological bibliography, as follows: "Work on the project, on which I have been engaged for the past several years under a grant from the National Science Foundation (aided by Dr. D. E. G. IRVINE), has proceeded slowly. This is a project that eventually the Society might take over, or at least cooperate in its execution. In due time, I shall renew the matter. Experienced, careful, accurate bibliographers trained in phycology (if such persons exists!) are needed to cover the literature in the minor language areas, particularly. The great difficulty here is finding persons with both talents."

Index Nominum Algarum

The president mentioned the importance of the Index Nominum Algarum, about which Dr. SILVA has written the following: "This is a second project on which I have been engaged for the past several years under a grant from the National Science Foundation [cf. Taxon 7: 251. 1958]. Again, the Society might take over this project or cooperate in its completion. As part of this project, I have been compiling annual increments of taxonomic changes and novelties. The question is this: is there any interest in having these annual lists published? We should note that the "Repertorium Plantarum Succulentarum" is such a list, and that it is published by the International Bureau of Plant Taxonomy with the financial support of the I.U.B.S. If there is any interest among phycologists, we should apply to the I.U.B.S. for financial help. The list for 1959 totals about 1,400 names and would cost about $ 500 to publish."

As these subjects are difficult to discuss without a certain time for deliberation, the president invited those who have ideas to mention them to himself, to Dr. SILVA, or to Dr. KOSTER.

Finances

A message from Dr. SILVA was read by Dr. GERLOFF: "In order that the individual membership fees may be retained at the very low level of $ 2.80, it is necessary for us to exploit other sources of financial help. Library subscriptions will go a long way toward keeping us solvent, but the annual phycological bibliography is a very expensive project that must be supported from outside the Society. The National Science Foundation is a possibility, but in consideration of the international importance of the project, UNESCO would seem more appropriate. We should certainly attempt to secure moderate funds from commercial enterprises. Several pharmaceutical houses in the U.S.A. are willing to cooperate in a plan, provided it would include contributions from a representative list of firms, both in this country and elsewhere. Certainly there are companies in Germany, France, Britain, and Japan (and elsewhere) that could well afford to participate in such an international program. If 10 or more companies participated, no more than $ 100 each per year would go a long way toward giving us the financial strength necessary to be really effective, especially in the publication of Phycologia. Would it be possible to appoint a committee to "sound out" the feasibility of such a program? Dr. GERLOFF has established an account in a Berlin bank. In view of several considerations (uncertainty of the Berlin political situation, irregularity of the affairs of the Society and of Phycologia), I have retained most of our funds in the Bank of California. A fairly large sum is in a London bank (representing the dues payments of British members). As soon as feasible, I shall transfer the funds to Dr. GERLOFF. As a long range plan, however, it seems practical to establish a local (Berkeley) fund solely for the purpose of financing the publication of Phycologia."

Financial cooperation from commercial enterprises seems very difficult in Europe, according to the president. Dr. DAVY DE VIRVILLE was afraid that it might be dangerous to be dependent upon industrial institutions.

Dr. GERLOFF said that the Berlin bank where he intends to open an account has a branch in Frankfurt. Those members who have not yet paid their subscription are invited to do so, as soon as the name of the bank has been announced [cf. Announcements].

The Secretary
J. TH. KOSTER

Fourth International Seaweed Symposium

Biarritz, France, 18–24 Sept. 1961

The Fourth International Seaweed Symposium, which was held in the Casino Municipal, Biarritz, was divided into a Section for Biology and Ecology and a Section for Chemistry and Utilization. There were 200 participants from 27 countries.

From 18–20 Sept. in the Section for Biology and Ecology 42 papers were read, three films and a set of colour slides were shown; in the Section for Chemistry and Utilization 30 papers, and on 22 Sept. two hors-congrès papers were read. On 21 Sept. a chiefly touristic excursion to San Sebastian (Spain), including an excellent meal, was made. On 22–24 Sept. collecting was done on excursions to Guéthary, Biarritz, and Hendaye. In the Section for Chemistry and Utilization a proposal was made by Mr. SERRE (Morocco) for the foundation of a "Centre International d'Étude et de Renseignements pour les Algues," which proposal was discussed on 23 Sept.

From the Symposium the urgent desire was sent to the F.A.O., now that utilization of marine algae is increasing, to ask governments and institutes to control and to protect the phycological resources, to encourage basic investigations, especially those on commercial species, as well as technological research on methods for collecting them. The International Seaweed Symposium, the International Phycological Society, and special institutes should be consulted. F.A.O. should determine the measures which are necessary, especially in the field of scientific documentation and in coordinating the investigations.

Social meetings in connection with the Symposium were: a reception by the Sénateur-Maire of Biarritz in the townhall on 19 Sept., a successful performance of Basque dances by the "Ballets Basques Oldarra" in the Casino Municipal on 20 Sept., and a banquet in the elegant "Hotel du Palais" offered by the president and the members of the Organizing Committee. – J. TH. KOSTER.

Announcements

International Phycological Society

Membership fees for the year 1962 are now payable. Dues (which include a subscription to *Phycologia*) are $ 2.80 (£ 1; DM 11,30) per annum for individual members, $ 5.60 (£ 2; DM 22,60) for organizational members. Payments should be made payable to the International Phycological Society and sent either to the treasurer (Dr. J. Gerloff) or to one of the regional sub-treasurers, as follows:

Dr. J. Gerloff Separatkonto, I. P. S. Nr. 64 41 5294, Berliner Disconto Bank A.G., Berlin-Steglitz, Schloßstr. 95, West Germany.
Dr. G. E. Fogg, Department of Botany, Westfield College, London, N.W. 3, England.
Dr. J. Th. Koster, Rijksherbarium, Leiden, Netherlands (postgiro nr. 9013 ten name van De Twentsche Bank N.V.).
Dr. P. C. Silva, Department of Botany, University of California, Berkeley 4, California, U.S.A.
Dr. Y. Yamada, Department of Botany, Hokkaido University, Sapporo, Japan.

Members who have not yet paid dues for the year 1961 are requested to do so at this time. Members who have received the reprint of the phycological literature list for 1959 should add $ 1 per copy to their dues payment. Prompt payment will eliminate the burdensome and expensive task of sending dues notices.

Die Überweisung der Beiträge kann entweder durch Banküberweisung oder Bankscheck erfolgen, oder durch Postscheck auf das Postscheckkonto der Berliner Disconto Bank (Berlin-West 78495) unter Angabe der oben genannten Konto Nr. der I.P.S. (64 41 5294). Ferner besteht die Möglichkeit die Überweisung durch Postanweisungen vorzunehmen, die ebenfalls auf die Berliner Disconto Bank ausgestellt werden müssen. Es wird darauf hingewiesen, dass in vielen europäischen Ländern die Überweisung durch Postanweisung (Auslandspostanweisung) die einfachste und billigste Transfermöglichkeit darstellt, da eine direkte Umrechnung der Landeswährung in DM erfolgen kan. Sofern die Beiträge für das Jahr 1961 noch nicht entrichtet sind, wird darum gebeten diese zusammen mit dem Beitrag für das Jahr 1962 einzuzahlen. Die Gesellschaft wäre dankbar wenn die Mitgliedsbeiträge bis spätestens zum 15. Febr. 1962 bezahlt würden.

La cotisation pour l'année 1962, payable à la Société phycologique internationale, peut être adressée dès maintenant au trésorier ou à l'un des sous-trésoriers dessus indiqués.

Phycologia

The ability of the Society to maintain the personal membership fee at the very low level of $ 2.80 depends upon active support of our journal by institutions throughout the world. Members are earnestly requested to urge their institutions to subscribe to *Phycologia*. The annual rate is $ 5.60. All subscriptions should be sent to the Editor.

The Fritsch Collection of Illustrations of Freshwater Algae

Professor F. E. FRITSCH used to cut the figures out of original papers about freshwater algae and mount them on sheets of paper which he kept in cardboard drawers. It was not always possible to do this because part of the text would have been lost in the process. However, some colleagues sent him two copies of their papers. Since his death the collection has been in the possession of the Freshwater Biological Association. Similar collections have been made by other phycologists and, like this one, have largely reflected the special interests of their makers. The Freshwater Biological Association has been able to get some temporary financial help so that the Collection can be much enlarged without any special emphasis on given groups of algae.

The Collection is now housed in steel filing cabinets and most of the additions are photocopies of original figures. The sheets are arranged according to a simple taxonomic scheme and so labelled that reference to the alphabetical index makes it possible to find any genus very quickly. At present, figures of over 15,000 species taken from more than 3,000 original works are in the Collection. Some algae have been figured many times, notably certain desmids, and the total number of pictures in the Collection exceeds 150,000; by the time that the financial grant ends, April 1964, the number will certainly be over 200,000.

The value of such a "pictorial herbarium" will be obvious to any phycologist and has been discussed elsewhere (29th Ann. Rep., Freshwater Biol. Assoc., 1961, pp. 21–23; see also Brit. Phycol. Bull. 1 (5): 18–21). This note is written to advertise its existence so that all who wish to do so can consult it. It is not possible to send the sheets out on loan except under the scheme by which they are insured, as they are virtually irreplaceable. It may be possible to send photocopies, but it is hoped that those interested will be able to come and consult the Collection at the Windermere Laboratory of the Freshwater Biological Association. – J. W. G. LUND.

Research Requests

The biology group of the Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena, California, U.S.A., would like to obtain soils from desert areas. Studies to be conducted on these soils include the isolation and identification of algae and other microorganisms. Interested persons may contact ROY E. CAMERON at the Laboratory.

At the request of the Sub-Committee on Botany of the Pacific Science Association, Dr. MARY BELLE ALLEN is preparing a list of cultures of marine phytoplankters that are currently being maintained. It will be appreciated if investigators having such cultures will send their lists to her at Kaiser Foundation Research Institute, S. 14th and Cutting Blvd., Richmond, California, U.S.A.

Research Grants

Fort Hays Kansas State College, with a grant from the Kansas Fish and Game Commission, is making a three-year survey of the plants of the Cheyenne Bottoms, one of the largest waterfowl refuges in the United States. EDWARD BRAZDA, a graduate student, is surveying the algae under the direction of HENRY J. MCFARLAND, Assistant Professor of Biology.

Under the International Educational Exchange Program (India Wheat Loan) of the Department of State, U.S.A., the Botany Department of the Banaras Hindu University, Varanasi, India, has received $ 35,000 in equipment for advanced research on the physiology and biochemistry of algae, particularly the nitrogen-fixing blue-green algae. Dr. R. N. SINGH was a participant under this program during 1959–60 and visited the U.S.A. He spent six months at the Department of Biochemistry, University of Wisconsin, working on a problem of nitrogen fixation by cell-free preparations from blue-green algae and on the electron microscopy of their cell structure. He spent two months visiting important centres of phycological, physiological, and biochemical research.

Recent Deaths

JOHANNES BOYE PETERSEN, Emeritus Professor of Botany, Botanisk Laboratorium, København, November 7, 1961.

GEORGE B. RIGG, Emeritus Professor of Botany, University of Washington, Seattle, July 10, 1961.

JOSEF SCHILLER, Professor, Botanisches Institut der Universität Wien, July 10, 1960. [Obituary and bibliography in Rev. Algol 5: 229–235.]

Botanica Marina

Internationale Zeitschrift für die Erforschung und Auswertung von Meeresalgen. International Review for Seaweed Research and Utilization. Revue Internationale pour l'Étude et l'Exploitation des Algues Marines. Vorsitzender des Herausgeberkollegiums: Prof. Dr. TORE LEVRING, Göteborg. Schriftleiter: Dr. HEINZ A. HOPPE, Hamburg-Altona. Redaktion: Studiengesellschaft zur Erforschung von Meeresalgen e.V., Hamburg-Altona, Eschelsweg 4. Verlag: Gram, de Gruyter & Co., Verlagsbuchhandlung, Hamburg 1, Messberghof. Es erscheinen jährlich 4 Hefte. Der Bezugspreis pro Jahr beträgt DM 28.– zuzüglich Versandkosten.

This important phycological journal recently completed its second volume with articles on phytoplankton of the Norwegian Sea (E. PAASCHE), morphological studies of *Isthmoplea sphaerophora* (E. JAASUND), culture of *Monostroma* (T. SEGI and W. KIDA), synthetic culture media of marine algae (M. R. DROOP), new species of *Gelidium* from China (K. C. FAN), and the distribution of iodine in *Laminaria hyperborea* (B. LARSEN and A. HAUG). A supplement has been announced: Marine phytoplankton in New Zealand waters, by VIVIENNE CASSIE (about 80 pp., 8 pls., DM 18.—).

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